

# SCANNING ELECTRON MICROSCOPY OF BOOK-LUNGS OF THE SCORPION<sup>1</sup>

## *HETEROMETRUS FULVIPES*

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The book-lungs have been considered as the ancestral arachnid respiratory organs (Kaestner, 1968) and are intermediate structures between the book-gills of merostomes and the tracheal system of the araneid spiders (Mill, 1972). Although a comprehensive account on the structure of a book-lung of scorpions and some other arachnids is available from the recent publications of Vyas and Laliwala (1972) and Mill (1972), the stereoscopic micrographs presented here reveal certain additional information about the structure of the lamellae of *Heterometrus fulvipes* and correct some misconceptions about the nomenclature of certain structures described by Mill (1972) in the anatomy of the arachnid book-lungs.

### MATERIALS AND METHODS

Live specimens collected from the Gujarat University Campus, Ahmedabad (India) were stored in scorpion preservative (Vyas, 1972) and were transported by air mail to University of Georgia, Athens, U.S.A. for scanning electron microscopy. The book-lungs were carefully taken out by dissecting the specimens under a stereoscopic binocular microscope and were transferred to 70% ethanol. Sections of the book-lungs passing through desired planes were cut. Preparation of samples for scanning electron microscopy involved dehydration, critical point drying and gold coating. Dehydration was performed by passing the samples through ethanol-amyl acetate grades. The tissue was critical point dried according to the method of Anderson (1956). Gold coating, at two different angles was done in a Varian VE - 10 vacuum evaporator with the specimens on the rotating stage. Because of the difficulty

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with specimen charging, the specimens had to be coated with four times the amount of gold usually used (800 - 1200  $\text{\AA}^0$  approximately). A cambridge stereoscan Mark 2A electron microscope was used for the observations. Micrographs of desired magnification were instantly obtained by the polaroid camera attached.

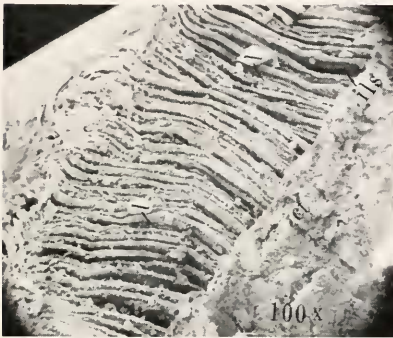


Plate 1

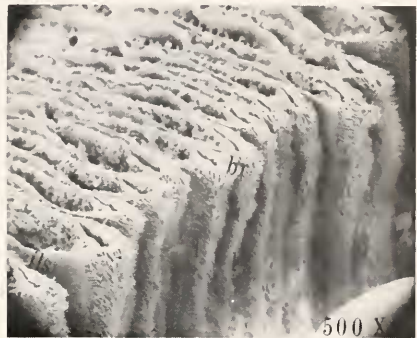


Plate 3



Plate 2

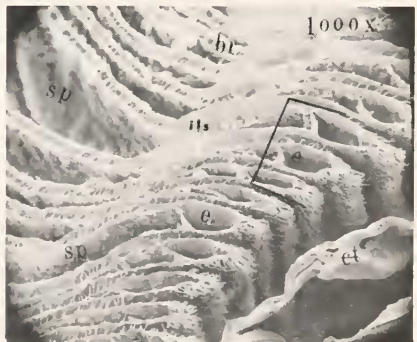
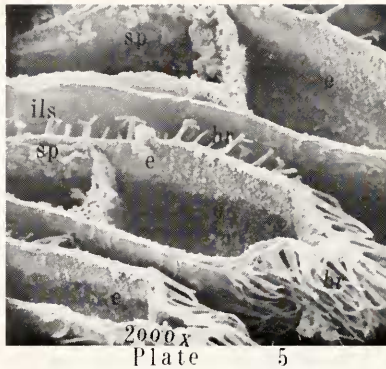


Plate 4

### OBSERVATIONS

On removing the connective tissue sheath (ct) from the atrial facet of the book-lungs a series of vertically arranged lamellae can be observed (plates-1,2). In *H. fulvipes* the number of the lamellae ranges from 140 to 150 (Vyas and Laliwala, 1972). As is known, while the atrial end of the lamellae remains free (plates-2,3), the other end attaches to the posterior wall of the pulmonary chamber. The space between two adjacent lamellae (plates-3,4,5) is known as inter-lamellar space (ils). The inter-lamellar spaces are continuous



with the space of the atrial chamber (at) which communicates to the exterior through stigmata (also called spiracles according to Stahnke, 1970).

In a longitudinal section each lamella appears as a hollow tubular structure (plates- 3,4,5). The lumen of the lamella (sp) is partitioned towards its atrial end and forms a small distinct space called the epithelial sinus (e). The outer wall of the lamellae is lined by cuticle (c) which frequently forms bristles (br).

### DISCUSSION

The above observations indicated that the 'lumina' in book-lungs described by Mill (1972) is comparable to the inter-lamellar space. Each lamellar loop contains a lumen (sp) of its own which is an extension of the pulmonary sinus. Hence in literature to avoid confusion instead of lumina (Mill, 1972), the usage of the term inter-lamellar space is recommended. Moreover, this term is very common in various text-books describing the structure of book-lungs. The cuticular bars mentioned by Mill (1972) are equivalent to bristles. These structures, at least in *Heterometrus* do not have the form of continuous bars between two lamellae. However, during process of breathing the bristles of the opposing facets serve as a means of preventing the lamellae from collapsing.

The magnified stereomicrograph of the atrial end of the lamellae revealed the presence of the epithelial sinus not observed earlier (Vyas and Laliwala, 1972) under light microscopy. The sinus along with its surrounding wall has been described as an epithelial glandular cell by Awati and Tembe (1956) in *Buthus*. According

to these authors, this part of the lamella receives the blood for respiration by the way of diverticula and not directly from the pulmonary sinus.

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### LITERATURE CITED

- ANDERSON, T. F. 1956. Electron Microscopy of Microorganisms In: Physical Techniques in Biological Research Vol. III G. Oster and A. Pollister, eds, Academic Press New York p. 177-240.
- AWATI, P. R. and TEMBE, V. B. 1956. *Buthus tamulus* (Fabr.). The Indian Scorpion: Morphology, Anatomy and Bionomics. Zoological Monographs No. 2, University of Bombay.
- KAESTNER, A. 1968. Invertebrate Zoology: Arthropod relatives, Inter Science publishers, New York, London, Sydney.
- MILL, P. J. 1972. Respiration in the Invertebrates. Macmillan.
- STAHNKE, H. L. 1970. Scorpion Nomenclature and Mensuration. *Ent. News*. Vol. 81. p. 297-316.
- VYAS, A. B. 1972. Taking the sting out of preserving scorpions. *Turttox News*. Vol. 49. p. 25.
- VYAS, A. B. and LALIWALA, S. M. 1972. Microanatomy of the Book-lungs of Scorpion and the Mechanism of Respiration. *Vidya-Gujarat University Journal*. Vol. 15. p. 122-128.

ABSTRACT — Early description of the book-lungs in the scorpion *Heterometrus fulvipes* included its gross anatomy and mechanism of respiration. The following study provides the first three dimensional stereoscopic observations of the lamellae of an arachnid book-lung. The investigation shows the presence of a well defined space called the epithelial sinus towards the atrial end of each lamella in *H. fulvipes*. Bristles on the outer surface of lamellae constitute separating bars and help prevent the lamellae from collapsing during the ventilatory movement of the book-lung. Distinction between the lumen within the lamellae and the inter-lamellar space is essential to avoid confusion. Institute of Ecology, University of Georgia, Athens, Georgia 30602, present address: University School of Sciences, Gujarat University, Ahmedabad - 9, India.

*Descriptors:* Scorpion, Scorpionida, Scanning electron microscopy, book lungs, anatomical terminology.